F/A-22 Advanced Tactical Fighter

Key features of the F/A-22 include low radar observability (with internal weapons carriage) and supersonic cruise capability in non-afterburning power, combined with superior maneuverability and excellent handling qualities. Other features critical to the F/A-22 concept of operations are an integrated avionics suite incorporating wide field-of-regard offensive and defensive sensors, an electronically scanned, active element radar array, and an advanced electronic warfare system with a variety of identification and countermeasures capabilities. Enhanced logistics features include an Integrated Maintenance Information System (IMIS) and advanced Diagnostics and Health Management (DHM) to achieve high sortie rates, reduced maintenance manpower, and improved deployability. Basic armament consists of six AIM-120C radar-guided air-to-air missiles, two AIM-9 infrared guided missiles, and a 20mm cannon. Alternatively, two 1,000 pound Joint Direct Attack Munition precision-guided bombs can be carried internally along with two AIM-120s and two AIM-9s.

Development of the F/A-22 started as the Advanced Tactical Fighter with Milestone 0 completed in 1983 and Milestone I in 1986. The F-22 program completed its Milestone II Defense Acquisition Board (DAB) and entered Engineering and Manufacturing Development (EMD) in July 1991. Since then, the program has undergone several major changes due to schedule delays, budget reductions, and cost growth. An independent Joint Estimating Team identified significant cost growth in EMD and recommended program restructuring. This restructure was approved by a February 1997 DAB. A primary element of the restructure was elimination of the four Pre-Production Vehicles. As a result, two EMD test aircraft and two Production Representative Test Vehicles (PRTV 1) were assigned as Operational Test aircraft. EMD was also increased by nine months to allow more time for avionics testing. The EMD flight test program began on September 7, 1997, with first flight of Aircraft 4001 at Edwards Air Force Base. In December 1999, a DAB delayed the Low-Rate Initial Production (LRIP) decision and designated the next block of six aircraft Production Representative Test Vehicles II (PRTV II).

F/A-22 testing progressed slowly during CY00, mainly due to late aircraft deliveries. In addition, aircraft deficiencies, including structural issues requiring onsite modifications, further delayed demonstrating performance in developmental test. The scheduled December 2000 LRIP DAB was deferred to allow additional time to complete Exit Criteria. The F/A-22 TEMP was approved in January 2001. In June 2001, in an attempt to improve executability of the program, the Air Force restructured the test program. The outcome was deferral of some testing to beyond the start of Initial Operational Test and Evaluation (IOT&E). In addition, planned IOT&E start date was delayed from August 2002 to April 2003. All LRIP Exit Criteria were completed and the DAB was held in August 2001. Initiation of LRIP was approved along with an increase in the F/A-22 production cost cap. To compensate for the cost increase, production quantity was reduced to 295 aircraft with the caveat that the Air Force could increase this quantity if production improvement programs yielded significant payoffs in reducing cost.

F-22 is designed to employ internally carried armament.

The F/A-22 Live Fire Test & Evaluation (LFT&E) plan includes evaluation of hydrodynamic ram structural damage, dry bay fire, and critical component separation. Aircraft 4001, previously used in the flight sciences testing, was transferred to serve as a Live Fire Test (LFT) target. LFT to date has included hydrodynamic ram vulnerability testing of the wing and aft fuel tanks; fire vulnerability testing of the wing attachment, aft side of fuselage, main landing gear (MLG), and airframe mounted accessory drive (AMAD) dry bays; and penetration vulnerability testing of avionics bays. High explosive threat effect tests were performed to evaluate component separation adequacy. In May 1999, the Air Force relaxed the vulnerability specification by 30 percent to accommodate increases in vulnerability determined as a result of LFT&E. Testing of wing leading edge dry bay fire, forward fuselage fuel tank hydrodynamic ram damage, and the performance of the on-board inert gas generating system are yet to be completed.

TEST & EVALUATION ACTIVITY

During CY02, additional test aircraft were delivered to the test force and progress was made in flight sciences and logistics testing. However, persistent fin buffet at higher angles of attack and a canopy "howl" phenomena added flight test points and delayed envelope expansion efforts. Avionics testing fell far behind the planned schedule due to slow deliveries of derivative software packages incorporating advanced functionality needed for IOT&E. Avionics testing was further hampered by the fact that delivered software was immature leading to in-flight instability and system shutdowns. The Air Force convened separate Fin Buffet and Avionics Red Teams in the spring/summer of 2002 to address these issues and then decided to again delay the planned start date of IOT&E from April 2003 to August 2003 in order to have more time to deal with known system deficiencies and problems in these and other areas.

Performance of the F119 engine has generally been excellent and all testing necessary for its Initial Service Release approval was completed by May 2001. Full-scale airframe static testing using airframe 3999 and the first of four planned fatigue lifetimes of testing using airframe 4000 have been completed and second fatigue life testing is in progress. Expansion of flight testing into the high-speed, high g-load regions of the performance envelope is ongoing with the only flight test aircraft (4003) that has the structural modifications and test instrumentation necessary to conduct this testing. Flight envelope expansion is critical to weapons integration and avionics test progress since the envelope must be opened to complete necessary testing in those areas. The program also continues to work to understand and identify appropriate modifications for higher than predicted aft fuselage temperatures and thermal management system deficiencies.

F/A-22 aircraft avionics flight test began in January 2001. The APG-77 radar met its detection range performance parameter and radar testing continues in conjunction with the Communications, Navigation, and Identification (CNI) and Electronic Warfare (EW) subsystems that provide the other components of integrated closed loop tracking. However, instabilities and problems with EW and CNI software have seriously hampered the progress of the avionics flight test program. Resolution of these instabilities and performance problems are essential to continued progress and have received major focus. The Flying Test Bed (FTB) assisted with in-flight data-link and missile launch detector development. It continues to play a role in the integration of avionics software and hardware components prior to their being tested on the F/A-22. The Avionics Integration Laboratory (AIL) in Seattle, the Tactical Avionics System Integration Laboratory (TASIL) in Fort Worth, and the newly activated Raptor AIL (RAIL) in Marietta, along with the FTB are key elements in the process that should eventually culminate in a stable, operationally effective, and suitable F/A-22 avionics suite being delivered to flight test and IOT&E.

Safe separation unguided missile launches have been conducted with both AIM-9 and AIM-120 missiles and were expanded into the supersonic flight regime during 2002. The first guided AIM-120C launch from the F/A-22 occurred in September 2001 with the missile guiding to within lethal radius of the target. Supersonic guided launches, essential to validate the F/A-22's supercruise combat capability, began in November 2002 with an AIM-9M and an AIM-120C being successfully launched in separate flight tests.

Testing of F/A-22 stealth characteristics has included measurements of both radar and infrared signatures and evaluations of stability over time and logistics testing. Measured radar signatures have been extremely consistent between test aircraft and are generally meeting system specifications. Stealth sustainability testing is in progress and several planned 50-hour Low Observability (LO) maintenance test blocks have been completed. Environmental risks in the LO area have been reduced and maintenance processes for restoration of Radar Cross-section have been developed.

Wing fuel tank hydrodynamic ram ballistic test and evaluation was completed in January 2002. Engine nacelle fire suppression system ballistic testing was started in May 2002 and was completed in late 2002. A realistic forward fuselage test article was manufactured to conduct forward fuselage fuel tank hydrodynamic ram damage ballistic tests.

TEST & EVALUATION ASSESSMENT

The 1991 Milestone II DAB directed an Operational Assessment (OA) to support the F/A-22 LRIP decision. The Air Force OA began in January 1998 and the report documenting results was published in April 2001. Numerous issues including main landing gear strut settling, environmental control system problems, intra-flight data link shortfalls, and missile launch detector performance, were identified. Aircraft brake and arresting tail hook design difficulties were highlighted as creating a potential for the F/A-22 to be forced to operate from longer airfields. The amount of specialized support equipment that may be necessary to maintain stealth performance could adversely affect mobility support requirements. The greatest risks to certification of F/A-22 for IOT&E were identified as avionics test progress, software development, flight envelope expansion, and test aircraft configuration. DOT&E concurs in this assessment that has been further reinforced by the ongoing F/A-22 flight test program.

During moderate to high angle of attack maneuvering vortices from the leading edge of the fuselage, engine inlets, and wings buffet the tail fins causing responses that could have serious strength and fatigue implications. Since only one F/A-22 flight test aircraft incorporates the structural modifications and special instrumentation to enable the flight envelope to be fully cleared to its airspeed, altitude, and g-load design limits, the program maintains a high schedule risk in clearing the required flight envelope prior to the Air Force's planned start of IOT&E in August 2003 while also characterizing and resolving the fin buffet issue. All test aircraft today have multiple operating limitations. All are monitored during flight for unacceptable loads/stresses. Missions have been terminated early as a result of exceeding monitored load and/or temperature limits. IOT&E requires both an adequate flight envelope and unmonitored flight clearance (without control room support to monitor loads/stresses during uninhibited maneuvering typical of visual "close-in" air combat and air combat training). The fin buffet issue could add additional restrictions (pitch and roll rates, angle of attack and g-loads, altitude thresholds for maneuvering).

Avionics software has encountered problems in processing and "fusing" information from multiple sensors tracking multiple targets resulting in shutdowns that necessitate operationally unacceptable restart procedures. This instability problem contributed to avionics test inefficiencies and limited the ability of developmental test to measure integrated system performance. Resolving avionics system instabilities and functionality issues requires development of numerous software fixes and extensive regression testing due to changes to software configuration, architecture, etc. Additional software problems are sometimes created during the resolution process, further complicating efforts to achieve the planned software development schedule. The current schedule may not allow sufficient time to incorporate and validate all necessary stability and functionality-related avionics modifications prior to the Air Force's planned start of IOT&E in August 2003. In an attempt to come to grips with this issue, OSD convened an independent Avionics Technology Red Team to assess F/A-22 avionics development status and plans in December 2002. This team is scheduled to provide its findings and recommendations in late January 2003.

Development and integration of fully integrated diagnostics has slipped to a software block that delivers after the Air Force's planned start of IOT&E in August 2003. Fully capable integrated diagnostics cannot be available until after a planned architecture change is implemented to add a "health and status" monitor function — necessary to allow maintenance personnel to operate the interface between planned support equipment and aircraft systems. Fully integrated diagnostics will not be available until Lot 2 aircraft, or later, when new common integrated processors are used. DHM is required for an adequate IOT&E suitability assessment. Without integrated diagnostics, maintenance carried out in accordance with the current F/A-22 maintenance concept will not be possible and contractor logistic support, to include special test equipment and personnel, will be required. Current indications are that some contractor-operated Special Test Equipment will be required to maintain the aircraft during IOT&E.

Initial guided missile launches were conducted at non-operationally realistic (slower) airspeeds as engineering build-ups to the Test and Evaluation Master Plan (TEMP) scenarios. Supersonic guided launches using TEMP scenarios have now begun. Some fully integrated guided missile test launches will be done concurrently with IOT&E or as part of a post-EMD effort. The Air Force intends to demonstrate that the captive-carry instrumented test vehicle (ITV) version of the AMRAAM missile is a valid Operational Test evaluation tool. The TEMP was revised to reflect the option to use ITV data in lieu of actual live launches in certain scenarios if approved by DOT&E; however, DOT&E has yet to approve this option. DOT&E believes that the largest F/A-22 development risk, from both a technical and schedule perspective, lies in the integration and validation of the advanced avionics suite with realistic air-to-air weapons employment. An event-driven start to IOT&E would have to include sufficient time to correct known deficiencies in fire control/weapons employment in order for the IOT&E to be adequate and credibly measure operational effectiveness and suitability.

A major part of the F/A-22 IOT&E evaluation will be based on results from the Air Combat Simulator (ACS), currently in development at the prime contractor's facility in Marietta, Georgia. The ACS must model four-ship employment in the dense surface-to-air and air-to-air threat and electronic signal environment that is impractical or too costly to generate in open-air trails. Development of the ACS, consisting of four domes and ten manned interactive cockpit stations, continues but slow progress in integrated avionics flight test affects Verification, Validation and Accreditation (VV&A) activities, necessary prior to initiation of IOT&E. Since the planned flight test program may not provide all data required for accurate ACS system characterization, the Air Force plans to use FTB and ground hardware-in-the-loop laboratory data to supplement flight test data in the ACS VV&A effort. A successful conclusion to IOT&E and F/A-22 EMD is dependent on the commitment of adequate resources to complete the necessary ACS development.

Technical and schedule risk are high, as is the probability that a successful IOT&E can begin as scheduled in April-October 2003 with an effective and suitable production-representative weapon system. Significant operational capability is being deferred until after the start of IOT&E and completion of EMD. Deferred testing includes ferry configuration, external stores, and JDAM carriage and release, full gun employment envelope, full use of the speed brake function, and numerous system specification compliance test points. Deferred mission avionics capabilities include JDAM employment, AIM-9X integration, helmet mounted cueing system integration, Joint Tactical Information Distribution System transmit capability, and transition to the production version of the Common Integrated Processor, with attendant changes to avionics core processing.

Results of the wing fuel tank hydrodynamic ram test indicate that, in the area tested, the redesigned wing performed as predicted and successfully withstood hydrodynamic ram effects. The accurate prediction of damage and residual strength for this test supports the analysis that predicts wing fuel tank vulnerability to hydrodynamic ram in critical structural components elsewhere on the wing.

Limitations on loading the aircraft to represent realistic flight loads with representative airflow were overcome using computer controlled hydraulic jacks pushing against the wings to simulate flight loads of a maneuvering airplane. A battery of five jet engines blew high velocity air across the wing, and the fuel tanks were filled with fuel. As a result, the test was conducted as if the aircraft were in flight and hit by an anti-aircraft artillery round.